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INSTRUCTION MANUAL

FOR THE

TRANSISTOR TEST SET
TYPE 275-A

ID24

BOONTON RADIO CORPORATION
BOONTON, NEW JERSEY
U.S.A.

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Printed in U.S.A.

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SECTION I

DESCRIPTION

GENERAL

The Transistor Test Set Type 275-A is a self-contained instrument for the precise measurement of basic transistor parameters over a wide range of operating conditions. The Test Set may also be used to measure the characteristics of diodes and other semi-conductor devices. Direct read-out alpha (short-circuit current gain, grounded base, h_{fb}), beta (short-circuit current gain, grounded emitter, h_{fe}), and input resistance (output shorted, grounded base, h_{ib}) is provided with variable emitter current and collector voltage from the internal supplies.

A specially designed measuring circuit, test oscillator, detector, emitter and collector power supplies, and a multi-function precision meter are housed in an aluminum cabinet designed for bench operation or for mounting in a standard 19-inch rack.

The measuring circuit incorporates precision resistance elements arranged to provide direct read-out of all parameters on a large, calibrated dial. Measurements are completely independent of signal level fluctuation and calibration is essentially permanent. The power supply polarities may be switched to measure either PNP or NPN type transistors. A test circuit is provided to insure that the operating potentials are correctly applied.

The test oscillator, which feeds the measuring circuit, is a conventional R-C type. The detector, which amplifies the unbalance output from the measuring circuit, is fed to the multi-function meter which may be switched to operate as a null indicator. Provision is also made for the use of an external detector.

Separate power supplies are provided for emitter current and collector voltage. Both supplies are regulated against line voltage changes and are continuously variable over a wide range. The output of both supplies is monitored by the multi-function meter which may be switched to read either current or voltage. Complete meter protection is provided through automatic meter range switching.

PANEL LAYOUT AND CONTROLS

All of the controls, indicators, and connection terminals necessary for normal operation of the Transistor Test Set are arranged in convenient functional order on the front panel of the instrument (Figure 1).

Power Switch

In the ON position, the Power Switch connects the Test Set to the power source.

SET-CHECK-MIN Switch

This switch has three positions: SET, CHECK, and MIN. In SET position the transistor test terminals are disconnected from the internal power supplies and the desired collector voltage (open circuit) and emitter current (short circuit) are set up. CHECK position is used to check that the current applied to the emitter-base terminals is correctly polarized for the transistor under test. The MIN position is used for adjusting the α-h_{ib}-β dial for a minimum indication during the actual measurement procedure.

Meter Switch

The Meter switch has four positions: V_{CB}, I_E, I_C, and MIN. In V_{CB} position the Panel Meter is connected to read collector voltage. In I_E position the meter indicates emitter current. With the switch in the I_C position the meter is connected to indicate collector current. The I_C position should only be used with a transistor connected to the test terminals and the SET-CHECK-MIN switch in the MIN position. In MIN position the meter is connected to indicate the minimum at balance. (See Figure 11 for conditions of balance.)

V_{CB} Volts Range Selector

This selector is used to select any of six ranges of collector voltage. Available full-scale ranges are 2, 5, 10, 20, 50, and 100 volts.

V_{CB} Control

The V_{CB} large knob provides coarse adjustment of the collector voltage furnished by the internal power supply. The small knob on the V_{CB} control provides a vernier control for fine adjustment of the collector voltage.

I_E Ma. Range Selector

The I_E ma. selector is used to select any of ten ranges of emitter current. Available full-scale ranges are .1, .2, .5, 1, 2, 5, 10, 20, 50, and 100 milliamperes.

I_E Control

The large knob on this control provides coarse adjustment of the emitter current furnished by the internal power supply. The small knob provides fine adjustment of the emitter current, except on the higher ranges where it becomes the basic control over the upper half of the meter scale.

NPN — PNP Switch

This switch has two positions, designated NPN and PNP, which are used to establish the polarity of the voltage and current applied to the test terminals.

α-h_{ib}-β Selector

The α-h_{ib}-β selector is used to select the parameter to be measured. Alpha (α) may be measured in the range of 0 to 1.0 or .9 to 1.0. h_{ib} may be measured in three ranges employing multiplying factors of .1, 1, or 10. Beta (β) measurements are made with the selector in the β position.

α-h_{ib}-β Dial

The α-h_{ib}-β dial (Figure 1) provides direct readings of α, β, and h_{ib}. Beta is read on the top scale at the fiducial line. Measurements of h_{ib} are read on the middle (OHMS) scale at the fiducial line. The h_{ib} dial reading is multiplied by .1, 1, or 10, depending upon the h_{ib} range used. Alpha is read on the

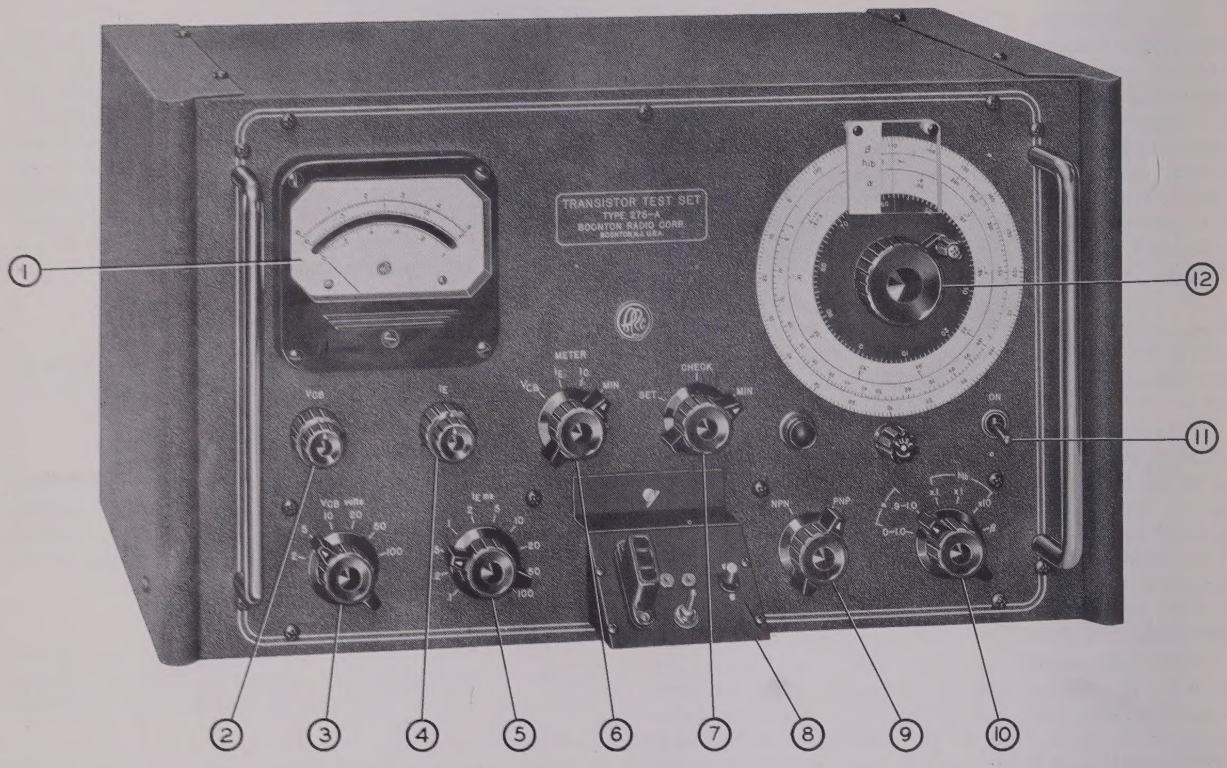


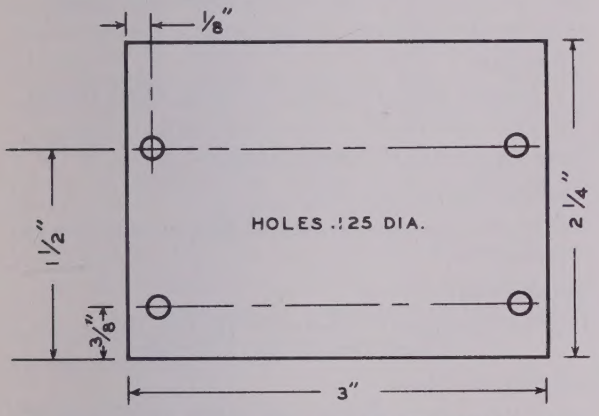
Figure 1. Front Panel Controls

1. Panel Meter
2. V_{CB} Control
3. V_{CB} Range Selector
4. I_E Control
5. I_E Range Selector
6. METER Switch
7. SET-CHECK-MIN Switch
8. Type 575-A Test Jig
9. NPN-PNP Switch
10. α-h_{ib}-β Selector
11. Power Switch
12. α-h_{ib}-β Dial

bottom scales; the upper set of figures being used when measuring on the 0 to 1.0 range, and the lower set of figures being used when measuring on the .9 to 1.0 range. A vernier interpolation scale, applicable to both α ranges, is available on the inner dial. This scale provides the last two significant figures in the measurement. For example, readings of between .8 and .9 on the 0 — 1.0 scale and 42 on the inner scale would be combined for an alpha reading of .842.

Panel Meter

The Panel Meter is a multi-function meter which indicates collector voltage, emitter current, collector current, or balance, depending upon the position of the Meter switch.



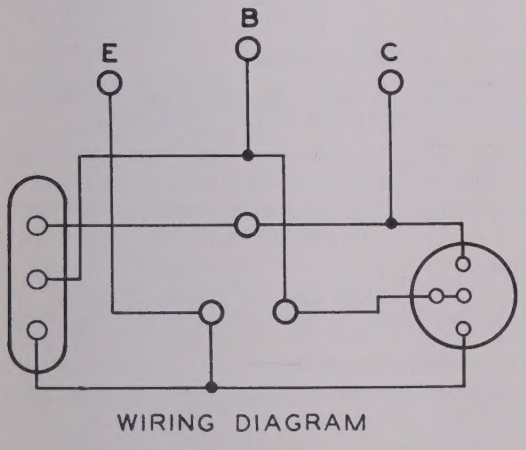


Figure 2. Type 575-A Test Jig

TEST TERMINALS AND CONNECTORS

Three test terminals are provided on the front panel for connection to the collector, emitter, and base terminals on the transistor under test. The terminals are combination binding post and banana plug connectors and are identified with the first letter of the appropriate transistor electrodes.

Type 575-A Test Jig

A special Test Jig (Type 575-A), shown in Figure 1, is supplied with each Transistor Test Set. The jig has three commonly used transistor sockets mounted on its face. The sockets are wired in parallel and connected to three banana plugs. When the banana plugs on the jig are plugged into the test terminals on the front panel of the Test Set, the test voltage and current supplied by the internal supplies are connected to all of the transistor sockets. The jig is designed so that the socket mounting plate may be readily removed and replaced with a plate fitted with other type sockets. A wiring diagram of the jig and dimensional sketch of the socket mounting plate are shown in Figure 2.

External Power Supply Connector

A 12-pin socket, J3, is provided at the rear of the Test Set (Figure 23) for the connection of external collector and emitter power supplies. By removing the jumper plug and replacing it with the furnished blank plug, properly wired (Figure 3), collector voltages up to 100 volts can be fed from an external supply. Emitter currents up to 100 milliamperes for h_{ib} measurements, and up to 5 amperes (intermittent operation) and 2 amperes (continuous operation) for alpha and beta measurements, can be similarly applied. When operating at emitter currents above 100 milliamperes, the base current (I_B) must be limited to 100 milliamperes dc.

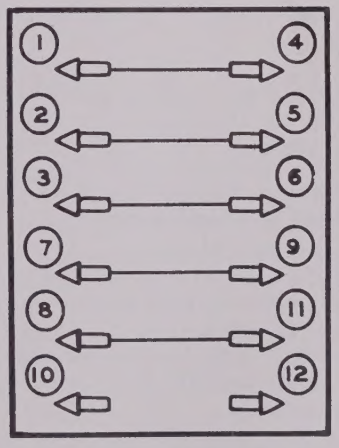


Figure 3. Wiring of Jumper Plug, P3.

External Detector Jack

A jack, J2, is provided at the rear of the Test Set (Figure 23) for connection of a sensitive, narrow-band (center frequency of 1000 cps), external detector (such as a wave analyzer) for measurements at very low signal level and I_E values below approximately 10 microamperes.

I_B Metering Connection

A terminal strip, J1, is provided at the rear of the Test Set (Figure 23) for the connection of an external meter for the measurement of base current, I_B. When in use, the shorting strap is removed from the terminal strip and the external meter is connected to

the two active terminals. With such a meter in the circuit, ac measurements are not recommended because of the effect of the meter resistance upon the measuring circuits.

Note: When the polarity of the internal power supplies is reversed with the NPN-PNP switch, the polarity of the external meter must also be reversed.

SECTION II

SPECIFICATIONS

Alpha (h_{fb}) Measurement Characteristics

RANGE: (a) 0.100 to 0.999
(b) 0.9001 to 0.9999

ACCURACY: (a) $\pm\left(0.1+\frac{0.09}{h_{fb}}\right)\%$*
(b) ±0.2%*

*For $f\alpha \geqslant 500$ Kc.

Beta (h_{fe}) Measurement Characteristics

RANGE: 7 to 200

ACCURACY: $\pm\left(0.6+\frac{30}{h_{fe}}\right)\%$*

*For $f\alpha \geqslant 500$ Kc.

Input Resistance (h_{ib}) Measurement Characteristics

RANGE: (a) 0.30 to 30 ohms
(b) 3.0 to 300 ohms
(c) 30.0 to 3000 ohms

ACCURACY: (a) ±3%*
(b) ±3%* (above 30 ohms)
(c) ±3%*

*For linear resistance.

Internal Test Oscillator

FREQUENCY: 1000 cps.

ACCURACY: ±5%

DETECTOR:
Internal: Null-meter
External: Connection jack provided

Collector Voltage (V_{CB}) Supply Characteristics

RANGE:
Internal: 0 to 100 volts D.C.
External: 0 to 100 volts D.C.

RIPPLE: < 20 mv. (115 v. line input)

REGULATION: ±2% or 0.25 volt for ±10% input line voltage

LOAD REGULATION: ± (0.2 v + 0.5%) volts

METERING:
Ranges: 0 to 2, 5, 10, 20, 50, 100 volts
Accuracy: ±1.5% f.s.

Emitter Current (I_E) Supply Characteristics

RANGE:
Internal: 0 to 100 ma. D.C.
External: 0 to 5 amps. D.C.* (intermittent operation)
0 to 2 amps. D.C.* (continuous operation)

*h_{fb} only; $I_b \leqslant 100$ ma. D.C.; I_E & I_C metered externally.

RIPPLE: < 1%

REGULATION: < 5% for ± 10% input line voltage

SOURCE IMPEDANCE: > 15 K ohms

METERING:
Ranges: 0 to 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100 ma.
Accuracy: ±1.5% f.s.

Base Current (I_b) Characteristics

RANGE: 0 to 100 ma. D.C.

METERING: Connection terminals provided for external meter.

Accessories

FURNISHED: Type 575-A Transistor Test Jig
Cinch-Jones P-306-CCT Plug

AVAILABLE: None

Tube Complement

1 — OA2	1 — 6C4
3 — OG3	2 — 6DQ6A
1 — 6AH6	1 — 12AT7
2 — 6BA6	1 — 12AX7

Physical Characteristics

MOUNTING: Cabinet for bench use; by removal of end bells, suitable for 19" rack mounting.

FINISH: Gray wrinkle, engraved panel (other finishes available on special order).

DIMENSIONS: Height: 10⅞" Width– 19$\frac{5}{16}$"
Depth: 12$\frac{13}{16}$"

WEIGHT:

Net:	46 lbs.	Gross Export:	95 lbs.
Gross Domestic:	55 lbs	Legal Export:	52 lbs.

Power Requirements

275-A: 105-125/210-250 volts, 50-60 cps. 90 watts

SECTION III

OPERATING INSTRUCTIONS

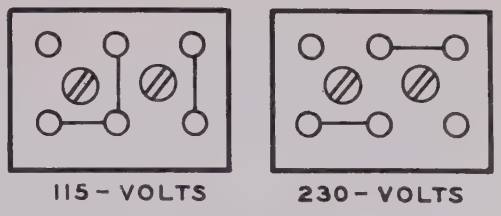


Figure 4. Connections for 115-volt and 230-volt Operation

INSTALLATION

Remove the Transistor Test Set from its shipping carton and place it in position on a test bench. If the instrument is to be installed in a rack, remove the end bells (See Section VI) to gain access to the mounting holes. Check to see that the jumper plug (identified by absence of cable clamp and plugged lead emergence hole) is plugged into the external power supply socket at the rear of the instrument (Figure 23). Then connect the power cord to either a 105 to 125 or 210 to 250-volt, 50 or 60 cps power source, as noted on the voltage plate on the rear of the instrument. A diagram showing the internal wiring changes required to convert from 115-volt to 230-volt operation, or vice versa, is shown in Figure 4.

Set the Power switch to the ON position and allow the instrument to warm up for at least 5 minutes. A 30-second time delay is included to protect the internal circuits.

OPERATING PRECAUTIONS

The following precautions should be observed during operation of the Transistor Test Set to avoid possible damage to the panel meter and the transistor under test, and to insure proper operation of the instrument.

1. Before connecting the Test Set to the power source, be sure that the jumper plug is plugged into the external power receptacle at the rear of the instrument.

2. Set the SET-CHECK-MIN switch to the SET position before plugging the transistor to be tested into the socket on the Test Jig.

3. Be sure that the NPN-PNP switch is positioned to provide the correct polarity for the transistor under test before setting the SET-CHECK-MIN switch to the MIN position. See step 9 in the Basic Set-up Procedure.

4. If a decrease in V_{CB} beyond the specified regulation, $\pm$ (0.2 v + 0.5%), is observed on the Panel Meter when switching from SET (or CHECK) to MIN, a collector-to-base short in the transistor under test is indicated and further testing should not be attempted as this might result in damage to the Panel Meter when the Meter switch is set to the I_C position.

5. Be sure that the V_{CB} and I_E values selected are within the specifications limits of the transistor under test.

6. If external power supplies are used, be sure that the maximum power does not exceed the permissible ratings listed in Section II.

7. Do not turn off the Test Set nor remove the transistor from the test terminals unless the SET-CHECK-MIN switch is in the SET position.

8. If the Test Set is turned off, wait at least 2 minutes before turning it on again.

OPERATING PROCEDURE

The procedure for setting up the Transistor Test Set for α, h_{ib}, and β measurements is the same, up to the point where the actual measurements are made. This procedure is given below as the Basic Set-up Procedure. Before attempting to operate the instrument, note the operating precautions given above.

Basic Set-up Procedure

1. Set the SET-CHECK-MIN switch to the SET position.

2. Connect the Test Jig to the test terminals on the front panel and set the Power Switch to the ON position.

3. Plug the transistor to be tested into the appropriate socket on the Test Jig.

4. Set the METER switch to the V_{CB} position.

5. Set the V_{CB} volts selector to the desired range position and adjust the large V_{CB} control and small V_{CB} control until the desired collector-to-base voltage is indicated on the Panel Meter.

6. Position the METER switch to I_E.

7. Set the I_E ma. selector to the desired range position and adjust the large I_E control and small I_E control until the desired emitter current is indicated on the Panel Meter. This value should be within the specification limits of the transistor under test.

8. Set the SET-CHECK-MIN switch to the CHECK position.

9. Operate the NPN-PNP switch first to the NPN position, then to the PNP position (if the transistor polarity is unknown) while observing the I_E indication on the Panel Meter. Set the switch to the position which causes the highest I_E indication. If the two I_E indications are identical a defective transistor or connection is indicated.

Note: *Germanium transistors, at very low emitter currents (10μa) may show little, if any, difference in current in either the NPN or PNP position. To insure a noticeable difference, increase the emitter current. Silicon transistor will cause relatively small differences in current indication in either the NPN or PNP position. The correct polarity is always indicated by the higher emitter current.*

10. Set the SET-CHECK-MIN switch to the MIN position.

11. To read collector current, set the Meter switch to the I_C position. At low emitter currents, for the specific transistor, the I_C reading may be greater than the I_E setting because of the collector-to-base leakage current, I_{CO}. This is likely to be true with germanium transistors at room temperature when the I_E chosen is one hundredth, or less, of the normal rated I_E.

12. Set the Meter switch to the MIN position and proceed with the α, h_{ib}, or β measurement as described below.

Alpha (α) Measurements

After the Transistor Test Set has been set up as described in the Basic Set-up Procedure, α measurements may be made as follows:

1. Set the α-h_{ib}-β switch to the α 0-1.0 range.

2. Adjust the α-h_{ib}-β dial until a minimum reading is indicated on the Panel Meter.

3. Read α directly at the fiducial point on the 0-1.0 scale on the α-h_{ib}-β dial. If alpha is greater than 0.9 and greater accuracy is desired, set the α-h_{ib}-β switch to the .9-1.0 expanded α range, readjust the dial for minimum indication, and read alpha directly on the .9-1.0 scale. The inner scale indicates the last two significant numbers of the α measurement in both cases.

4. Set the SET-CHECK-MIN switch to the SET position before removing the transistor from the Test Jig socket to protect the transistor from damage.

h_{ib} Measurements

After the Transistor Test Set has been set up as described in the Basic Set-up Procedure, h_{ib} measurements may be made as follows:

1. Set the α-h_{ib}-β selector to the desired h_{ib} range.

2. Adjust the α-h_{ib}-β dial for a minimum indication on the Panel Meter.

3. Read h_{ib} directly at the fiducial point on the h_{ib} (OHMS) scale on the dial and multiply by the appropriate h_{ib} range factor.

4. Set the SET-CHECK-MIN switch to the SET position before removing the transistor from the Test Jig socket to protect the transistor from damage.

Beta (β) Measurements

After the steps given under Basic Set-up Procedure have been completed, β measurements may be made as follows:

1. Set the α-h_{ib}-β selector to the β position.

2. Adjust the α-h_{ib}-β dial for a minimum indication on the Panel Meter.

3. Read β directly at the fiducial point on the β scale.

4. Set the SET-CHECK-MIN switch to the SET position before removing the transistor from the Test Jig socket to protect the transistor from damage.

USE OF EXTERNAL POWER SUPPLIES

External power supplies, furnishing power within the limits specified in Section II, may be connected to the 12-pin socket at the rear of the instrument. An unwired mating plug is furnished with the Test Set for this purpose. The power supply controls (I_E and V_{CB}) and the current and voltage metering circuits are inoperative in this application. To connect external power to the instrument, proceed as follows:

1. Disconnect the Test Set from the power source.

2. Wire the extra plug as shown in Figure 5.

3. Remove the jumper plug and connect the wired plug in its place.

4. Follow the Basic Set-up Procedure, omitting steps 4, 5, 6, 7, and 11.

5. Follow the procedure for α, h_{ib}, and β measurements.

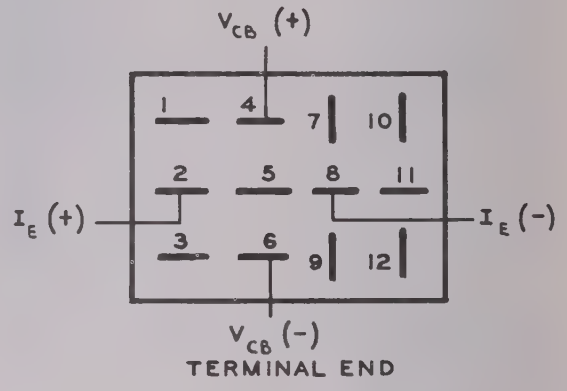


Figure 5. Wiring of Extra Plug for Connection of External Power Supplies

USE OF INTERNAL POWER SUPPLIES WITH EXTERNAL EQUIPMENT (INTERNAL METERING NOT CONNECTED)

The Transistor Test Set power supplies may be connected to external equipment by means of the 12-pin socket at the rear of the instrument. In this application the Test Set metering circuits are inoperative. To connect to the Test Set power supplies, proceed as follows:

1. Disconnect the Test Set from the power source.

2. Wire the extra plug as shown in Figure 6.

Note: *Polarity must be observed and interconnections must be made external to the Test Set.*

3. Disconnect the jumper plug and connect the wired plug in its place.

4. Reconnect the Test Set to the power source.

USE OF INTERNAL POWER SUPPLIES WITH EXTERNAL EQUIPMENT (INTERNAL METERING CONNECTED)

The Test Set power supplies, together with the internal metering circuits may also be connected for use with external equipment. The connections are made directly to the E, B, and C test terminals on the front panel. The standard jumper plug must be in place at the rear of the instrument.

Note: 1. *For some applications it might be desireable to remove the oscillator tube, V1, in order to remove the 1000 cps audio signal from the emitter terminals.*

2. *Under these conditions, the I_C position of the Meter switch is active and care must be taken if meter damage is to be avoided. Alternatively, a jumper may be connected between pins 4 and 10 on the jumper plug (Figure 3) thus shorting the meter in the I_C position.*

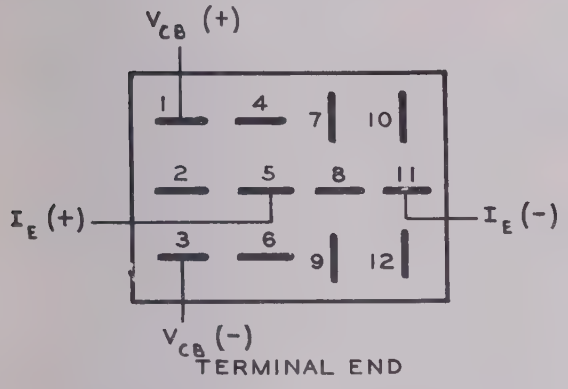


Figure 6. Wiring of Extra Plug, Using Internal Power Supplies to Power External Equipment

SECTION IV

PRINCIPLES OF OPERATION

GENERAL

A simplified block diagram of the Transistor Test Set is shown in Figure 7. The instrument consists of a measuring circuit, which is the heart of the Test Set, a stable 1-kc oscillator, a sensitive detector of wide dynamic range, and three power supplies.

MEASURING CIRCUIT

The equivalent circuit of the basic measurement on the Test Set is shown in Figure 8. When the linear potentiometer ($R_1 + R_2 = R_T$) is moved to a position where the signal voltage (V) between the base of the transistor and ground is a minimum, the small signal Alpha of the transistor is a linear function of the angular position of the potentiometer.

An expanded Alpha range is achieved simply and stably as shown in Figure 9. The R_V adjustment is required to correct for unit-to-unit variations in the total resistance of the linear measuring circuit potentiometer R_T.

If the circuit in Figure 8 is modified to the circuit in Figure 10, in which R_3 is a fixed resistance and

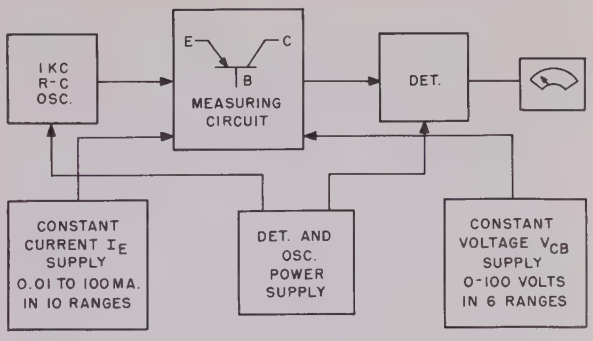
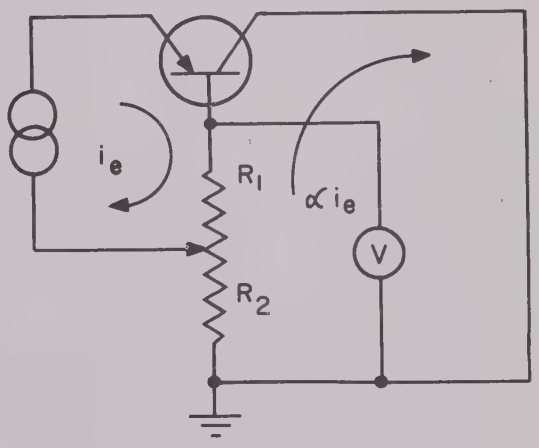


Figure 7. Transistor Test Set — Block Diagram

the potentiometer (R_T) is now used as a variable resistance, the small signal beta of the transistor is a linear function of the potentiometer.

The variable ratio arm bridge circuit shown in Figure 11 measures h_{ib}. Potentiometer (R_1 and R_2) provides the two variable ratio arms of the measuring circuit, and standard resistance R_S and the unknown resistance h_{ib} serve as the other arms. The potentiometer position required to make V a minimum is then calibrated in terms of the resistance value of h_{ib}.



$$\text{When } V = 0,\ i_e R_1 = \alpha\, i_e (R_1 + R_2)$$

$$\text{so } \alpha = \frac{R_1}{R_1 + R_2} = \frac{R_1}{R_T}$$

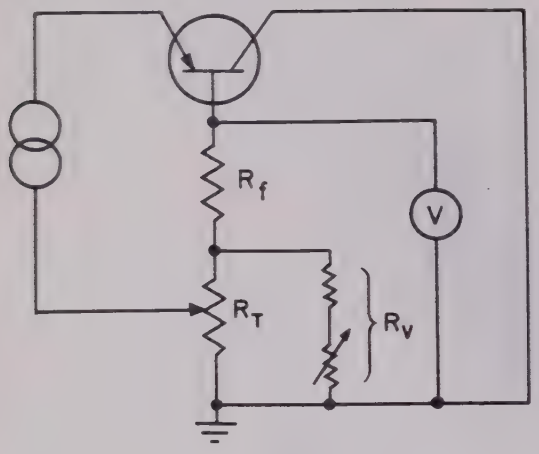
$$\text{if } R_1 + R_2 = R_T$$

Figure 8. AC Equivalent Circuit — Alpha Measurement

AUDIO OSCILLATOR

The oscillator is a simple RC Wien Bridge type with a fixed frequency of 1 kc. Output from this circuit, which is coupled to the measuring circuit through an audio transformer (T_2) having a ratio of 20 to 1, has an internal impedance of 5 ohms and an open-circuit output of 0.035 volts at test terminals E and B. Selection of reliable components and use of sufficient feedback make this a stable, trouble-free signal source. The source impedance is suitably varied by series resistors selected by the α-h_{ib}-β selector to

keep the rms ac-to-dc emitter current ratio sufficiently small to avoid troublesome harmonic generation. See Section V, "Sources of Error" for a discussion of rms ac-to-dc emitter current ratio.



$$R_T' = \frac{R_V R_T}{R_V + R_T}$$
$$R_f = 9 R_T'$$

Figure 9. AC Equivalent Circuit — Expanded Alpha Range

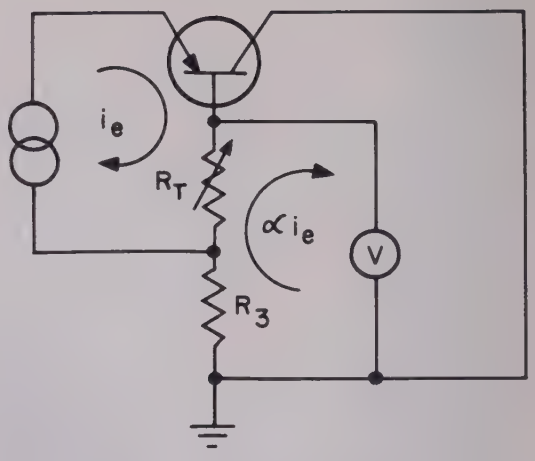
AMPLIFIER DETECTOR

The amplifier detector circuit consists of two amplifiers, a cathode follower, and an averaging rectifier. DC output from the circuit is applied to the meter and a dc voltage is fed back to the grids of each stage, as in an automatic gain control circuit, to extend the dynamic range of the indicator and permit a highly sensitive indication of the minimum, without auxiliary level controls. Feed back of dc also prevents possible damage to the meter by the large signal at the input of the detector when the potentiometer arm is far off the balance point.

POWER SUPPLIES

There are three power supplies: two are used for the transistor emitter and collector biasing, and the third is used to supply the internal oscillator and detector.

The emitter power supply is a constant current type supply which has a very high output impedance and full-scale ranges of 0-0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, and 100 milliamperes, covering most low and medium power transistors. Coarse and fine controls permit very precise setting of the emitter bias. Because of the high internal resistance, the bias magnitude, which is set by shorting the emitter and base terminals for transistor protection, is not affected when the transistor is placed in the circuit. Also, inserting different transistors has no effect on the I_E selected. A simplified schematic of the I_E supply is shown in Figure 12. Current through the tube is adjusted from less than 0.5 to 100 milliamperes by the

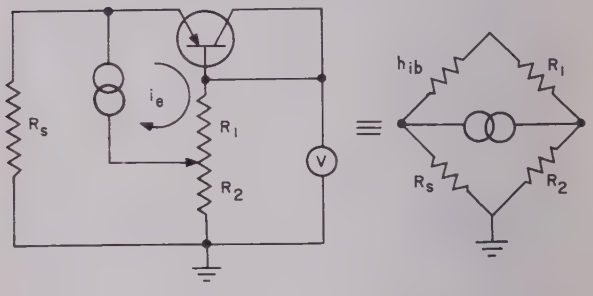


When $V = O$, $i_e R_T = \alpha\, i_e (R_T + R_3)$

so $\alpha = R_T / R_T + R_3$

but $\beta = \frac{\alpha}{1-\alpha} = \frac{R_T}{R_3}$

Figure 10. AC Equivalent Circuit — Beta Measurement



Where $h_{ib} = R_s \times \frac{R_1}{R_2}$

at null, $V = O$

Figure 11. AC Equivalent Circuit — h_{ib} Measurement

variable cathode resistor R_C. The emitter current ranges below 5.0 milliamperes are obtained by a current divider in the plate circuit, since the resulting power dissipation is very low. The breakdown diode (Z) protects the emitter-base junction of the transistor by limiting the high open-circuit voltage that develops because of the large impedance of the power supply.

The collector power supply is an electronically regulated constant voltage source with full-scale ranges of 0-2, 5, 10, 20, 50, and 100 volts. Like the emitter power supply this circuit allows easy, accurate selection of the desired V_{CB}. A current regulating tube improves the stability of the reference tube voltage versus power line fluctuations. This is especially important at low V_{CB} values. The internal ac and dc impedances are so low that neither switching

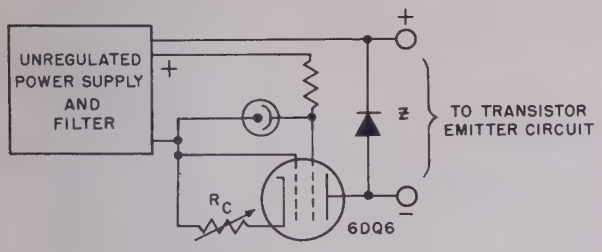


Figure 12. Simplified Circuit — Constant Current I_E Supply

in the transistor nor I_C variation has significant effect on the value of the voltage set. The ac output resistance, which is less than 15 ohms, acts as an ac short to the several megohm output resistance of the transistor under test.

SECTION V

SOURCES OF ERROR

MEASUREMENT OF TRANSISTORS ($f\alpha$ BELOW 500 KC)

The Transistor Test Set is designed for, and accuracy specifications are accordingly given for, transistors with $f\alpha$ greater than 500 kc. Transistor emitter-base regions have finite diffusion time, producing a phase shift between emitter and collector current. This phase shift, in turn, causes residual voltage to remain across R_1 and R_2 or R_T (Figure 8): the greater the phase shift, the higher the residual voltage remaining and the higher the meter reading becomes at balance. This is shown by the $f\alpha$ versus null depth curve in Figure 13.

CALCULATION VERSUS DIRECT READING FOR BEST α AND β ACCURACY

Betas in the 14 to 200 range can be determined more accurately by direct measurement on the Transistor Test Set than by calculation from α using the $\beta = \frac{\alpha}{1-\alpha}$ relationship. For betas below 14, however, it may be found that improved accuracy is obtainable by means of calculation from α. Betas above 200 are of course out of the direct range of the Test Set and therefore must be determined by calculation from α. See Figures 14 through 17 for a comparison of α and β accuracies obtainable by direct measurement on the Test Set and by calculation.

PARASITIC OSCILLATION

While every effort has been made to check all available transistors (including some uhf developmental types) to insure that parasitic oscillation will not occur during transistor measurements, it is possible that some special purpose transistors will be encountered which will exhibit parasitic oscillation. If this oscillation occurs, it will typically prevent a null, shift or fluctuate the null, or cause an erratic and "jumpy" meter indication in the vicinity of null. To check for parasitic oscillation, apply finger capacitance or connect a small capacitance across the test terminals on the Test Set and observe the Panel Meter. A shift in the null is an indication of probable parasitic oscillation. Connection of a suppression circuit across the test terminals will eliminate this oscillation.

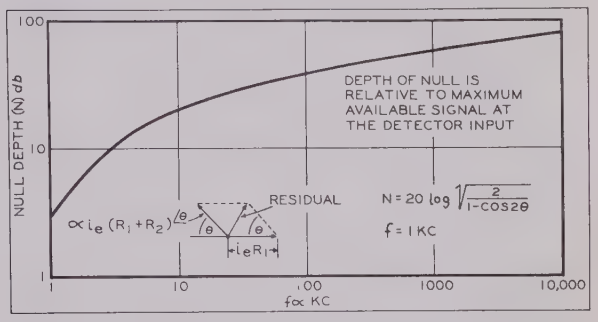


Figure 13. Null Depth Versus $f\alpha$

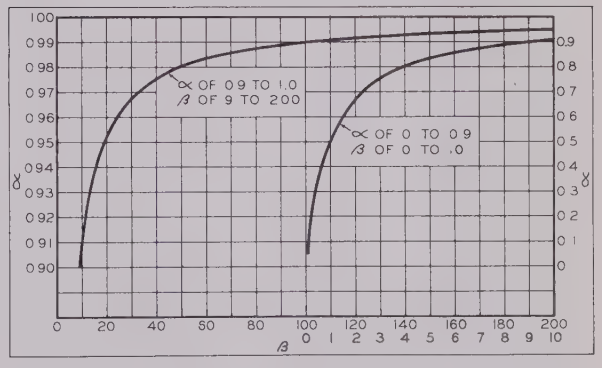


Figure 14. α Versus β from $\alpha = \frac{\beta}{\beta+1}$ or $\beta = \frac{\alpha}{1-\alpha}$

TRANSISTOR SOCKET CONTACT RESISTANCE

When working with h_{ib} measurements below approximately 10 ohms, it is important that low contact resistance be maintained at the transistor test socket terminals. If this resistance becomes high enough to form a significant part of the measurement, it is obvious that erroneous h_{ib} indications will result.

EFFECTS OF AC SIGNAL LEVEL ON THE MEASUREMENT

Every effort, consistant with simplicity of design, has been made to maintain an ac signal level which

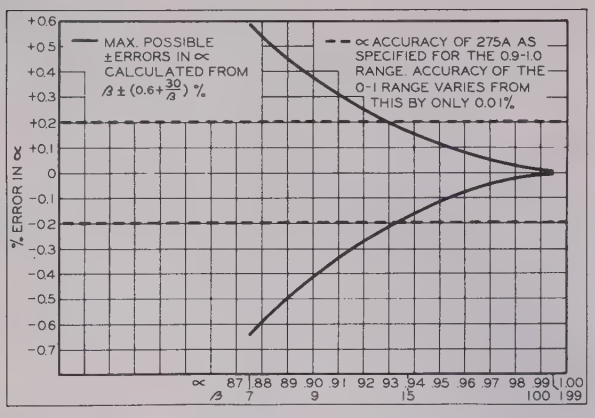

MAX. POSSIBLE ±ERRORS IN ∝ CALCULATED FROM β ± (0.6+30/β) %
∝ ACCURACY OF 275A AS SPECIFIED FOR THE 0.9-1.0 RANGE. ACCURACY OF THE 0-1 RANGE VARIES FROM THIS BY ONLY 0.01%
% ERROR IN ∝
+0.6 +0.5 +0.4 +0.3 +0.2 +0.1 0 -0.1 -0.2 -0.3 -0.4 -0.5 -0.6 -0.7
∝ 87 88 89 90 91 92 93 94 95 96 97 98 99 100
β 7 9 15 100 199

Figure 15. ∝ Accuracy by Measurement on the 275-A Versus Accuracy by Calculation from β

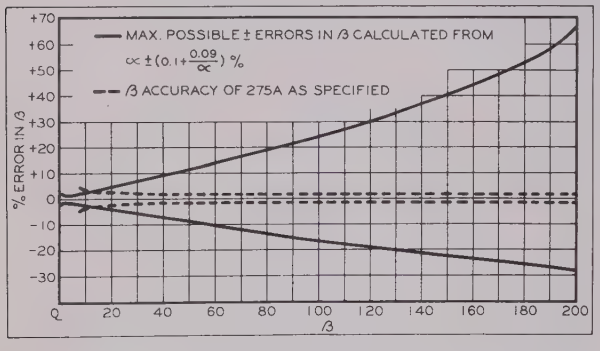

MAX. POSSIBLE ± ERRORS IN β CALCULATED FROM ∝ ± (0.1+0.09/∝) %
β ACCURACY OF 275A AS SPECIFIED
% ERROR IN β
+70 +60 +50 +40 +30 +20 +10 0 -10 -20 -30
0 20 40 60 80 100 120 140 160 180 200
β

Figure 16. β Accuracy by Measurement on the 275-A Versus Accuracy by Calculation from ∝ on 0-1.0 Range.

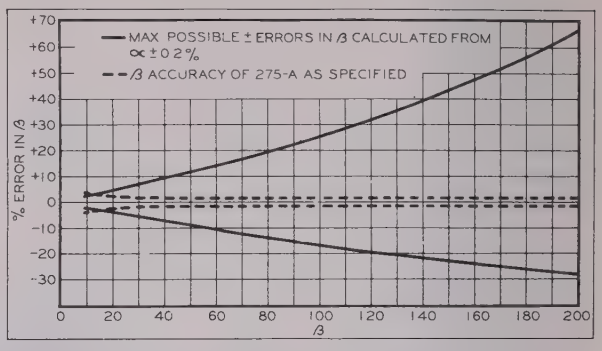

MAX POSSIBLE ± ERRORS IN β CALCULATED FROM ∝ ± 0.2%
β ACCURACY OF 275-A AS SPECIFIED
% ERROR IN β
+70 +60 +50 +40 +30 +20 +10 0 -10 -20 -30
0 20 40 60 80 100 120 140 160 180 200
β

Figure 17. β Accuracy by Measurement on the 275-A Versus Accuracy by Calculation from ∝ on the 0.9-1.0 Range.

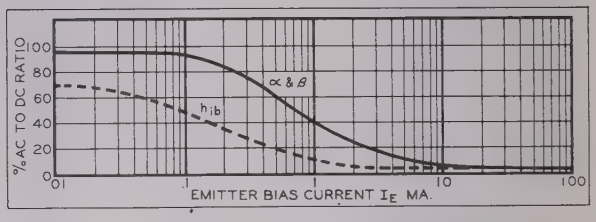


Figure 18. Ratio of Signal (RMS) to DC Emitter Biasing Current for a Typical Germanium Transistor as Measured on the 275-A

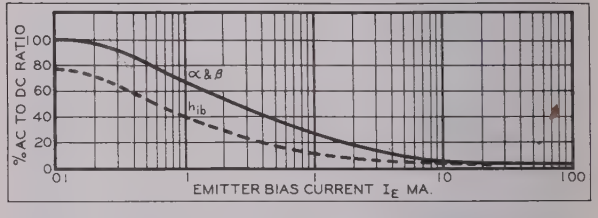


Figure 19. Ratio of Signal (RMS) to DC Emitter Biasing Current for a Typical Silicon Transistor as Measured on the 275-A.

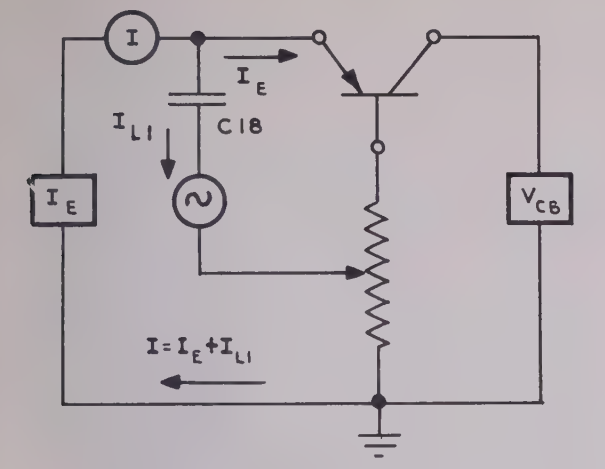
is sufficiently low to provide for measurement under small-signal conditions. The ratios of the 1000 cps test signal current to the dc emitter bias current for ∝ and h_{ib} measurements on both a typical Germanium and Silicon transistor, are given by the curves of Figures 18 and 19. The errors introduced at very low bias currents (10 to 100 μa), where the ac to dc ratios are largest, are not significant in most cases. For ∝ and β, the errors incurred are very small compared to other methods of measurement, due primarily to the null technique used.

Maximum accuracy may be accomplished in this low-current measurement area by attenuating the ac signal (This is done by shunting the primary of the oscillator transformer, T2.) and using a sensitive, narrow-band external detector tuned to 1 kc.

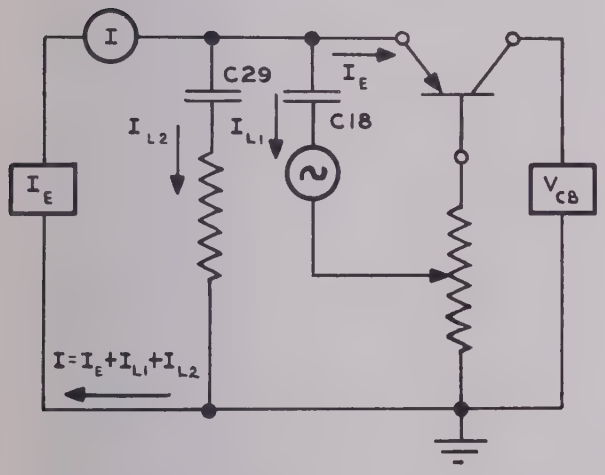
∝, β h_{ib} MEASUREMENTS AT LOW EMITTER CURRENTS

In all measurements, a capacitor, C18, is in series with the oscillator (Figure 20A) and its leakage current, if any, is registered as part of the emitter bias current on the Panel Meter. Typically this leakage current is infinitesimal (< 0.1 μa). However, should it be felt that an error exists in measurements of low emitter currents (10-100 μa), it would be advisable to measure the leakage current of the capacitor and correct the I_E setting by adding the leakage current to the I_E setting. This measurement can be made by connecting a sensitive micro-ammeter in series with the green lead of the secondary of the oscillator transformer, T2 (Figure 23). It is advisable to remove the oscillator tube, V1, when making the measurement. If the leakage current exceeds 3 μa, the capacitor should be replaced.

In addition to the above mentioned capacitor, there is another capacitor, C29, in the circuit for h_{ib} measurements (Figure 20B). This capacitor is in series with the R_S arm of the bridge. Leakage current through the capacitor is registered as part of the emitter bias current on the Panel Meter. For maximum accuracy of h_{ib} measurements at low bias currents (10 to 100 μa) this leakage current can be measured and added to the I_E current setting.



(A) ∝, β Measurement Circuit



(B) h_{ib} Measurement Circuit

Figure 20.

To measure the leakage current, disconnect the green lead from capacitor C29 (Figure 22) and insert a sensitive micro-ammeter in the circuit (positive terminal connected to the capacitor). Remove the oscillator tube, V1, set the desired I_E current, and switch the SET-CHECK-MIN switch to MIN. Allow sufficient time for the capacitor to charge fully before reading the leakage current. Typically this leakage current is of the order of 0.5 μa. If it is more than 2 μa, the capacitor is not operating according to specifications and should be replaced.

The capacitor has a finite charging time of approximately 15 seconds. When making h_{ib} measurements, allow at least this amount of charging time after switching the SET-CHECK-MIN to MIN, before making the measurement.

SECTION VI

MAINTENANCE

GENERAL

All the components of the Transistor Test Set are accessible when the cover and baseplate are removed. When performing maintenance work on the underside of the chassis, remove the Test Jig and rest the Test Set on its carrying handles.

REMOVING COVER AND BASEPLATE

To remove the Test Set cover and baseplate, proceed as follows:

1. Remove the four screws and spacer that fasten each end bell to the cover, and remove the end bells.
2. Remove the three screws along the bottom edge at the rear of the cover and the three screws along the top edge at the front of the cover. Lift the cover off the instrument, pulling the power cord through the hole in the cover.
3. Remove the four screws that fasten the baseplate to the bottom of the instrument and remove the baseplate.

REPLACEMENT OF TUBES

All of the tubes in the Test Set are replaceable with commercially available tubes. When a fault is traced to a particular tube, that tube should be replaced and any necessary adjustment procedures should be performed. The procedures to be performed after tube replacement are given in the table below.

Tube Replaced	*Adjustments Required*
V1	Oscillator Adjustments
V2,3,4,10	None
V5,6	I_E Power Supply Adjustment
V7,8,9,11,12	V_{CB} Power Supply Adjustment

ADJUSTMENT AND CALIBRATION

The Transistor Test Set is completely adjusted and calibrated at the factory and should not normally require readjustment or recalibration except in the case where certain tubes are replaced because they have become worn beyond their useful life.

Special Equipment Required

The only special equipment required to perform field adjustment and calibration of the Transistor Test Set is a precision, adjustable ratio transformer having the following characteristics:

1. Ratio — continuously variable, 0 to 1.0.
2. Frequency Range — sufficient to cover 1000 cps ±5%.

3. Accuracy of Indicated Ratio:

$$\pm\ (0.001\% + \frac{0.0006\%}{\text{Ratio}})$$

4. Phase Angle (Unloaded) — Approximately 0.15 milliradians.

5. Resolution — continuous.

6. Terminal Linearity — 0.001%.

Calibration of the $\propto$ Ranges

Connect the ratio transformer to the test terminals on the front panel of the Test Set as shown in Figure 21. The ground connection may be made at one of the cover screws for a "cover on" calibration check, or by clipping to the bare, tinned wire connecting potentiometer R58 and R68 (Figure 22) for a calibration check with the cover removed.

Set the I_E controls and the V_{CB} controls for zero indication on the Panel Meter and switch the SET-CHECK-MIN switch to the MIN position.

To check the calibration of the ~~0-0.1~~ 0-1.0 $\propto$ range, adjust the ratio transformer to a ratio of 0.10000 and then adjust the $\propto$-h_{ib}-β dial for minimum indication on the Panel Meter. The dial should read 0.10000 (within the accuracy specifications of the instrument) on the ~~0-0.1~~ $\propto$ range scale. Repeat the procedure for transformer ratios of 0.50000, 0.95000, and 0.99000, checking to see that the dial indication is the same as the transformer ratio setting in each case. Since there is no adjustment in this range, a calibration error is an indication of a defective precision potentiometer, R62 (Figure 22) or mechanical slippage of the dial on the potentiometer shaft. If the potentiometer is defective, it should be replaced. Mechanical slippage of the dial on the potentiometer shaft may be eliminated by resetting the dials so that the large dial indicates 1 on the $\propto$ 0-1 range and the small dial indicates zero at the stop at the extreme counter-clockwise position of the drive.

To check the calibration of the 0.9-1.0 $\propto$ range, set the transformer ratio to 0.90100 and then adjust the $\propto$-h_{ib}-β dial for minimum indication on the Panel Meter. The dial should read 0.90100 (within the specified accuracy of the instrument) on the 0.9-1.0 $\propto$ range scale. Repeat the procedure for transformer ratios of 0.95000, 0.99000, and 0.99900, checking to see that the dial indication is the same as the transformer ratio setting in each case. If the calibration is out on this range, set the transformer ratio to 0.90100 and adjust the $\propto$-h_{ib}-β dial to 0.90100 on the 0.9-1.0 $\propto$ range scale. Adjust R58 (Figure 22) until a minimum reading is indicated on the Panel Meter. Recheck the calibration at the other transformer ratio settings. If the calibration is still off, readjust R58 at the 0.90100 ratio setting to correct for the error.

Calibration of the β Range

Connect the ratio transformer to the test terminals as shown in Figure 21. Set the transformer ratio to 0.90000 and adjust the $\propto$-h_{ib}-β dial for minimum indication on the Panel Meter. The dial should read 9 (within the specified accuracy of the instrument) on the β scale. Repeat the procedure for transformer

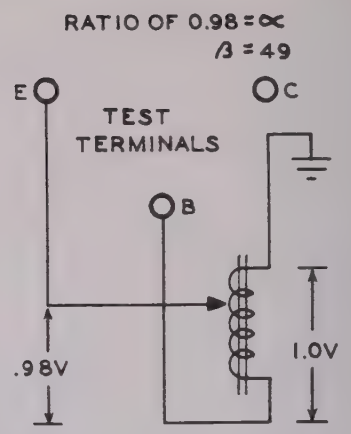


Figure 21. Ratio Transformer Connections to 275-A for Calibration of $\propto$ and β Ranges.

ratio settings of 0.95000, 0.98000, 0.99000, and 0.99500. The dial indication should be 19.0, 49.0, 99.0, and 199.0 respectively for these settings. If the calibration is out, set the transformer ratio to 0.99000 and adjust the $\propto$-h_{ib}-β dial to read 99. Adjust R68 (Figure 22) until the Panel Meter indicates a minimum reading. Recheck the calibration at the other transformer ratios. If the calibration is still out, readjust R68 slightly at the 0.99000 ratio setting to correct for the error. If other β calibration points are needed, they may be calculated from the expression $\propto = \beta/1 + \beta$.

Calibration of the h_{ib} Ranges

To check the calibration of the h_{ib} ranges precision resistors ($\pm$0.1%) of the following values are required: 5, 25, 250, and 2500 ohms.

Set the METER switch to MIN, the SET-CHECK-MIN switch to MIN, and the $\propto$-h_{ib}-β switch to h_{ib} x.1. Short test terminals E and B on the Test Set and turn the dial toward zero. The Panel Meter indication should be at minimum when the dial is at the stop or within two divisions (on the inner dial) of the stop. If a minimum reading cannot be obtained at this point on the dial, set the dial at the stop and adjust R88 (Figure 22) for a minimum meter reading. Remove the short across test terminals E and B, and connect a 25-ohm precision resistor across these terminals. Adjust the dial for a minimum meter reading. The dial should read 250 (within the specified accuracy of the instrument) on the h_{ib} x.1 scale. If the calibration is off, reconnect the short across terminals E and B, and readjust R88 with the dial against its zero stop. Do not exceed the two-division limit on the inner dial.

Set the $\propto$-h_{ib}-β switch to the h_{ib} x1 position and connect a 5-ohm precision resistor across test terminals E and B. Adjust the dial for a minimum meter reading and observe the dial reading on the h_{ib} x1 scale. The dial should read 5 (within the specified accuracy of the instrument). Repeat the procedure using 25 and 250-ohm resistors across the test terminals to check the 25 and 250 points on the h_{ib} x1 scale. If the calibration is off, check precision resistor

R87 (Figure 23) and replace if defective. Recheck the calibration of the dial. Errors in this range may be caused by loose screws on the I_B link on the rear of the chassis.

Set the $\propto$-h_{ib}-β switch to the h_{ib} x10 position and connect a 50-ohm precision resistor across test terminals E and B. Adjust the dial for a minimum meter reading and observe the dial on the h_{ib} x10 scale. The dial should read 5 (within the specified accuracy of the instrument). Repeat the procedure using 250 and 2500-ohm resistors across the test terminals to check the 25 and 250 points on the h_{ib} x10 scale. If the calibration is off, check precision resistor R86 (Figure 23) and replace if defective. Recheck the calibration of the dial.

Note: *Use of an external detector (such as a wave analyzer) with higher gain and selectivity than the Test Set detector will provide improved accuracy during the calibration checks.*

Oscillator Adjustments

Frequency

Variable capacitor C38 (Figure 23) in the oscillator has a range sufficient to shift the oscillator frequency approximately $\pm$2% about 1000 cps. It is factory adjusted for minimum interaction between the 1000 cps signal and harmonics of 60 cps. If interaction is noted, as indicated by a slight "flutter" of the meter pointer when the $\propto$-h_{ib}-β dial is set slightly off of a minimum, it may be reduced by adjustment of this capacitor. The capacitor should be adjusted until the "flutter" is reduced to zero. This is particularly important to users whose power line frequency is 50 cps, because, as previously stated, the factory adjustment is made for 60 cps.

Output Level

To check the output of the oscillator, proceed as follows:

1. Remove the jumper plug from the rear of the instrument.

2. Connect a 2% audio VTVM across the E and B test terminals on the Test Set.

3. Set the SET-CHECK-MIN switch to MIN, the METER switch to MIN, and the $\propto$-h_{ib}-β selector to $\propto$.

4. Adjust R25 (Figure 22) until the audio VTVM indicates 0.035 volts.

5. Disconnect the audio VTVM and connect a distortion analyzer across the primary of the oscillator transformer, T2 (across R17, Figure 24, Board "A").

6. The distortion should not be more than 1%. If the distortion is more than 1%, replace the oscillator tube, V1.

7. Replace the distortion analyzer with a frequency meter or other frequency measuring equipment.

8. The oscillator frequency should be 1000 cps within $\pm$5%. If the frequency deviates from 1000 cps by more than $\pm$5%, and cannot be brought into specifications by adjustment of C38, one of the following components in the oscillator circuit is probably defective: R5, R12, C2, or C10. Also see paragraph 1 under "Frequency".

Calibration Check of the Panel Meter

The V_{CB} and I_E meter calibration may be checked by connecting an appropriate ½% of full scale meter to the test terminals on the front panel of the Test Set. For V_{CB} checks the standard meter is connected across terminals C and B. For I_E checks, the standard meter is connected across test terminals E and B. The SET-CHECK-MIN switch is positioned to MIN and the METER switch is set to the appropriate position. The Panel Meter reading should be the same as the standard meter reading within $\pm$2% of full scale.

If the Panel Meter is out of calibration on the 0.1 ma. I_E range, the Panel Meter is defective. If the Panel Meter reading is out of calibration on one of the other I_E range positions or one of the V_{CB} ranges, the shunt or series resistor for that particular range is probably defective. When the meter calibration is within specifications on the 0.1 ma. I_E range but is off on all other I_E and V_{CB} ranges, R57 (Figure 22) should be adjusted as follows:

1. Connect the standard meter across test terminals E and B.

2. Set the SET-CHECK-MIN switch to MIN, the METER switch to I_E, and the I_E range selector to the 1.0 ma. range.

3. Adjust the I_E controls for a 1.0 ma. reading on the standard meter.

4. Adjust R57 until the Panel Meter reads 1.0 ma.

5. Check the remaining I_E ranges from .2 ma. to 100 ma. and, if necessary, readjust R57 to bring all readings within the specification.

V_{CB} Power Supply Adjustments

Load Regulation

To check the regulation of the V_{CB} power supply under load conditions, proceed as follows:

1. Connect the Test Set to power through a Variac and adjust the Variac for 115 volts.

2. Set the METER switch to I_C, the V_{CB} range selector to the 2-volt range, the V_{CB} controls fully counterclockwise, the SET-CHECK-MIN switch to MIN, and the I_E range selector to the 100 ma. range.

3. Connect a 20-ohm ($\pm$5%), 5-watt resistor and a dc voltmeter (set to the 5-volt range) across the C and B test terminals on the Test Set.

4. Turn R60 (Figure 22) fully counterclockwise and adjust R92 until the standard meter reads zero.

5. Turn the V_{CB} controls fully clockwise. The standard voltmeter should read not less than 2 nor more than 3 volts.

6. If the voltmeter reads less than 2 volts, readjust R92 as in step 4.

7. Adjust the V_{CB} controls for a 2-volt reading on the standard voltmeter. Note that I_C is approximately 100 ma. as indicated on the Test Set Panel Meter.

8. Set the METER switch to the V_{CB} position.

9. Disconnect the 20-ohm resistor from the test terminals.

10. Adjust the V_{CB} controls for a precise 2-volt reading on the Test Set Panel Meter.

11. Reconnect the 20-ohm resistor to the C and B test terminals. The V_{CB} indication on the Panel Meter should not vary by more than 0.21 v.

12. If the V_{CB} indication varies more than 0.21 v adjust R60 slightly clockwise.

13. Readjust R92 for zero indication on the Panel Meter with the V_{CB} controls set fully counterclockwise.

14. Repeat steps 9 through 13 until the V_{CB} indication varies less than 0.21 v when the 20-ohm load is connected across the test terminals.

15. Repeat steps 7 through 12 for a V_{CB} setting of 100 v, using a 1000-ohm (±5%), 10-watt resistor. The variation should not exceed ±0.7%.

Line Regulation

To check the Test Set under changing power line conditions, proceed as follows:

1. Connect the Test Set to power through a Variac and adjust the Variac for 115 volts.

2. Set the METER switch to V_{CB}, the V_{CB} range selector to the 2-volt range, and the SET-CHECK-MIN switch to MIN.

3. Connect a 20-ohm (±5%), 5-watt resistor across test terminals C and B.

4. Adjust the V_{CB} control for a precise 2-volt reading on the Panel Meter.

5. Adjust the Variac for +10% (125 v) and −10% (105 v) around 115 v.

6. If the meter reading varies more than ±0.25 volts, advance R60 slightly clockwise.

7. Adjust R92 with the V_{CB} control at minimum until the Panel Meter reads zero.

8. Repeat steps 4 through 7 until the meter reading does not vary more than ±0.25 v.

9. Recheck Load Regulation steps 9 through 13.

10. Repeat steps 1 through 9 for a V_{CB} setting of 100 v using a 1000-ohm (±5%), 10-watt, resistor. The variation should not exceed ±2%.

11. If the power supply will not regulate within the specifications, one of the following tubes is probably defective: V12, V7, V8, V9, V10, and V11.

I_E Power Supply Adjustment

The only adjustment provided in the I_E supply is R31 (Figure 22). This control is used to set the minimum output of the I_E ranges as indicated by the front panel meter. To adjust for zero scale reading on each range, proceed as follows:

1. Connect the Test Set to a variac set to 115 v.

2. Set the Meter switch to I_E and the I_E range selector to 100 ma.

3. Turn the I_E controls to minimum (fully counterclockwise).

4. If the meter does not indicate zero, adjust R31 for a zero indication.

5. Switch the I_E range selector to the 0.1 ma. range. The meter should still indicate zero. If it does not, readjust R31.

TROUBLE SHOOTING

It will be found that most of the troubles encountered on the Transistor Test Set are the result of tubes which have deteriorated. A trouble-shooting chart, voltage and resistance data, and a complete overall schematic of the Test Set have been included herein as trouble-shooting aides. Symptoms and probable causes for some common troubles which might be encountered are included in the trouble-shooting chart. It should be noted that the probable causes given do not constitute a complete listing of possibilities, and that the troubles described may be caused by defective components, not mentioned, which are in the circuits affected.

SOCKET VOLTAGES

Voltages measured at the tube socket terminals of a typical Transistor Test Set are given in the table below. All voltages shown are dc to chassis ground. Filament voltage is 6.3 ac across filament terminals. NC indicates no connection. All measurements were made with a 100-megohm 3% VTVM, with the Test Set controls set as follows:

Control	*Position*
Power Switch	ON
I_E Range Selector	1 ma.
V_{CB} Range Selector	2 volts
Meter Switch	V_{CB}
SET-CHECK-MIN	MIN
α-h_{ib}-β Selector	α 0 — 1.0
NPN — PNP Switch	PNP
α-h_{ib}-β Dial	00

SOCKET RESISTANCE MEASUREMENTS

Resistances measured at the tube socket terminals of a typical Transistor Test Set are given in the table below. All measurements are in ohms dc measured to the chassis ground. Measurements were made with an ohm meter of ±3% accuracy. Controls were set in same positions as for the voltage measurements except that the instrument was disconnected from the power source.

TROUBLE-SHOOTING CHART

Symptom	*Probable Cause*	*Remedy*
1. No meter indication with Meter switch in I_E, V_{CB}, or I_C position.	Jumper plug not in socket at rear of instrument.	Connect jumper plug.
2. When instrument is turned on with Meter switch in V_{CB} position, meter "pegs" full-scale stop.	Defective tube V8, V9, V11, or V13.	Replace tube.
3. Meter "pegs" full-scale stop with Meter switch in I_E position.	Open meter shunt resistor R46 through R54.	Replace resistor.
	Defective tube V6.	Replace tube.
	Open contact on Meter switch S3 (deck E, position 2)	Repair open.
	Open contact on I_E range switch S6 (deck A, range position in use).	Repair open.
	Defective tube V6.	Readjust R31
4. Full-scale meter reading not obtainable with I_E control.	Defective meter series resistor R80 through R85.	Replace tube.
	Defective meter shunt resistor R46 through R54.	Replace resistor.
	R31 misadjusted.	Readjust R31
5. A "near zero" meter reading not obtainable with V_{CB} control.	Open contact on Meter switch S3 (deck C, position 1)	Replace resistor.
6. A full-scale meter reading not obtainable with V_{CB} control.	or V_{CB} range switch S7 (deck B, range position in use).	Repair open.
	R31 misadjusted.	Readjust R31
	Defective meter series resistor R80 through R85.	Replace resistor.
7. Meter does not indicate with Meter switch in V_{CB} position.	Open meter series resistor R80 through R85.	Replace resistor.
	Defective tube V9, V11, or V12.	Replace tube.
8. Meter indication is erratic with Meter switch in MIN or I_E position.	Defective I_E control R41.	Replace control.
9. Error in h_{ib} measurements.	Defective standard resistor R86, R87, or R88.	Replace resistor.
	Defective capacitor C29.	Replace capacitor.
	Loose I_B link connection.	Tighten screws.
10. Broad null indication on Panel Meter.	Transistor under test is defective or has cut-off frequency of 500 kc or less.	See Figure 13 for null depth versus $f \propto$.
	Transistor under test is oscillating.	See "Parasitic Oscillation", Section V.
	Defective tube V1, V2, V3, or V4.	Replace tube.

Voltage Measurements At Tube Socket Terminals

Tube		*Pin Number*								
Circuit Symbol	*Type*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
V1	12AT7	−80	−150	−150	Fil.	Fil.	−60	−150	−150	Fil.
V2	6BA6	−155	−150	Fil.	Fil.	−110	−105	−150		
V3	6BA6	−155	−150	Fil.	Fil.	−54	−120	−150		
V4	6C4	NC	NC	Fil.	Fil.	81	−155	−140		
V5	0A2	−3	NC	NC	−150	−3	NC	NC		
V6	6DQ6A	NC	Fil.	NC	−3	−150	NC	Fil.	−120	
V7	6DQ6A	NC	Fil.	NC	110	−28	NC	Fil.	0	
V8	12AX7	−28	−59	−59	Fil.	Fil.	−59	−85	−86	Fil.
V9	0G3	−2	NC	NC	−86	−2	NC	−86		
V10	0G3	−160	−240	NC	NC	−160	NC	−240		
V11	0G3	NC	−170	NC	NC	−86	NC	−170		
V12	6AH6	−240	−240	Fil.	Fil.	−170	−162	−240		
V13	6N030	NC	Fil.	Fil.	NC	0	NC	0		

Resistance Measurements At Tube Socket Terminals

Tube		*Pin Numbers*								
Circuit Symbol	*Type*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
V1	12AT7	130K	240K	89K	85K	85K	50K	500K	90K	89K
V2	6BA6	500K	95K	92K	92K	570K	1.1M	95K		
V3	6BA6	1.4M	100K	92K	92K	240K	1M	100K		
V4	6C4	NC	NC	92K	92K	18.5K	1.45M	100K		
V5	0A2	22K	NC	NC	100K	22K	NC	NC		
V6	6DQ6A	NC	96K	NC	22K	95K	NC	96K	96K	
V7	6DQ6A	NC	19K	NC	35K	26M	NC	19K	19K	
V8	12AX7	2.8K	1M	50K	∞	∞	1M	160K	55K	
V9	0G3	20K	NC	NC	65K	20K	NC	65K		
V10	0G3	50K	130K	NC	NC	50K	NC	130K		
V11	0G3	NC	85K	NC	NC	65K	NC	85K		
V12	6AH6	130K	130K	∞	∞	87K	54K	130K		
V13	6N030	NC	∞	∞	NC	0	NC	19K		

APPENDIX

Calculation of h_{ie}, h_{ic}, and h_{fc}

Transistor parameters h_{ie}, h_{ic}, and h_{fc} may be readily calculated from direct measurements of α, β, and h_{ib} on the Transistor Test Set:

$$h_{ie} = h_{ic} = \frac{h_{ib}}{(1-\alpha)\,(1-h_{rb}) + h_{ob}\,h_{ib}} \qquad (1)^*$$

Since, typically, $h_{rb} << 1$, $(1-h_{rb}) \sim 1$, and $h_{ob}\ h_{rb} << 1$, under small-signal, low-frequency conditions, equation (1) may be reduced to equation (2) which results in an error of 10% for $\alpha = 0.99$ and decreases with a decrease in α:

$$h_{ie} = h_{ic} \sim \frac{h_{ib}}{1-\alpha} \sim h_{ib}\,(1+\beta) \qquad (2)$$

$$h_{fc} = \frac{h_{rb}-1}{(1-\alpha)\,(1-h_{rb}) + h_{ob}\,h_{ib}} \qquad (3)^*$$

Under the assumptions and within the limits of error set forth for equation (2), equation (3) may be similarly reduced to equation (4):

$$h_{fc} \sim \frac{1}{1-\alpha} \sim -(1+\beta) \qquad (4)$$

*Reference — Sylvan, T. P., "Conversion Formula for Hybrid Parameters", Electronics, April 1, 1957, p. 188 and 190.

HYBRID PARAMETER CROSS REFERENCE CHART

Parameter	CONFIGURATION														
	Common Base					*Common Emitter*					*Common Collector*				
	**prop. IRE Std.*	*Alt. A*	*Alt. B*	*Alt. C*	*Alt. D*	**prop. IRE Std.*	*Alt. A*	*Alt. B*	*Alt. C*	*Alt. D*	**prop. IRE Std.*	*Alt. A*	*Alt. B*	*Alt. C*	*Alt. D*
Input Resistance with Output Shorted	h_{ib}	h_{ib}	h_{11b}	$\frac{1}{r_{11b}}$	h_{ee}	h_{ie}	h_{ie}	h_{11e}	$\frac{1}{r_{11e}}$	h_{bb}	h_{ic}	h_{ic}	h_{11c}	$\frac{1}{r_{11c}}$	h_{bb}
Forward Short — Circuit Amplification factor	h_{fb} $-\alpha$	α_{fb}	h_{21b}	α_{ce}	h_{ce}	h_{fe} β	α_{fe}	h_{21e}	α_{cb}	h_{cb}	h_{fc}	α_{fc}	h_{21c}	α_{eb}	h_{eb}
Reverse open — circuit voltage amplification factor	h_{rb}	μ_{rb}	h_{12b}	μ_{ec}	h_{ec}	h_{re}	μ_{re}	h_{12e}	μ_{bc}	h_{bc}	h_{rc}	μ_{rc}	h_{12c}	μ_{be}	h_{be}
Output Conductance with input open	h_{ob}	h_{ob}	h_{22b}	$\frac{1}{r_{22b}}$	h_{cc}	h_{oe}	h_{oe}	h_{22e}	$\frac{1}{r_{22e}}$	h_{cc}	h_{oc}	h_{oc}	h_{22c}	$\frac{1}{r_{22e}}$	h_{ee}

*275A Terminology

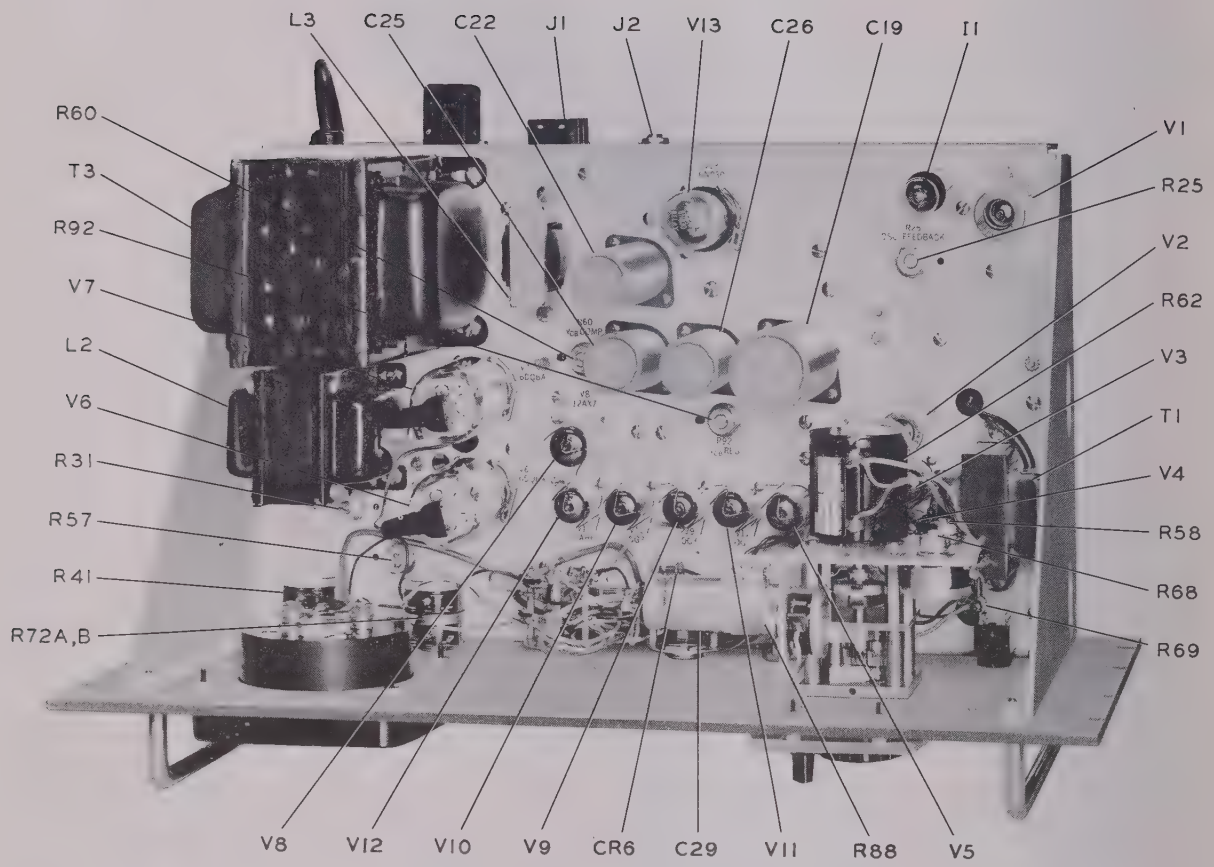


Figure 22. 275-A Chassis — Top View

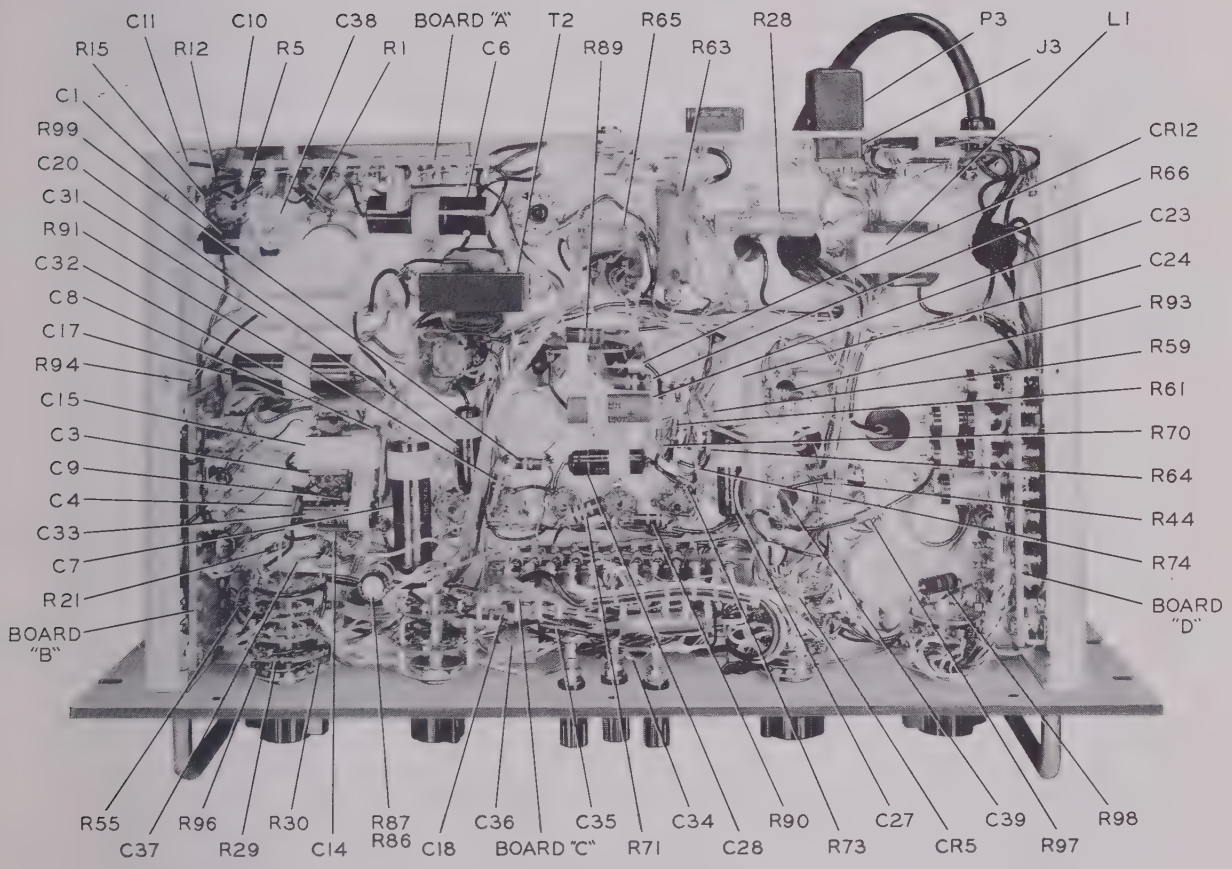
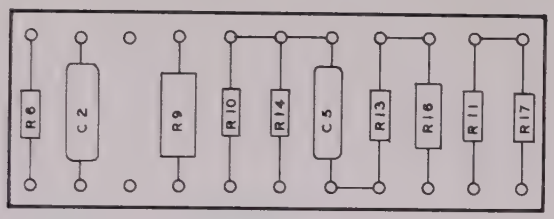
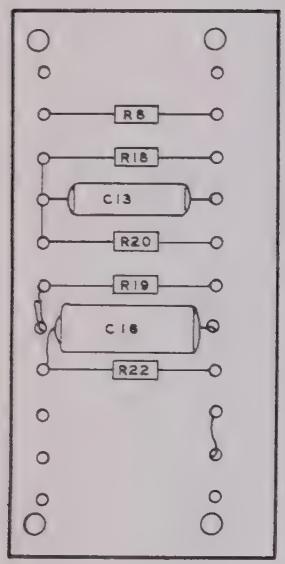


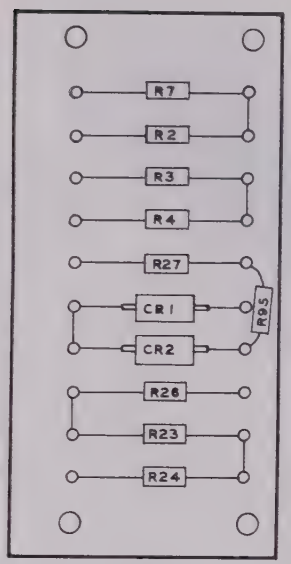
Figure 23. 275-A Chassis — Bottom View



Terminal Board "A"

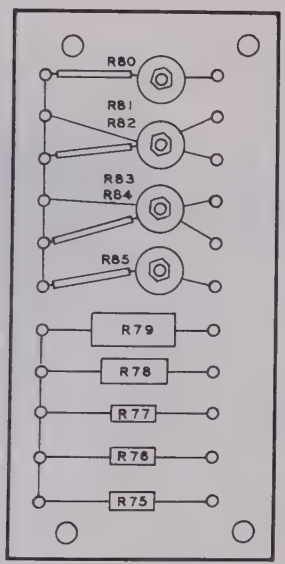


Top

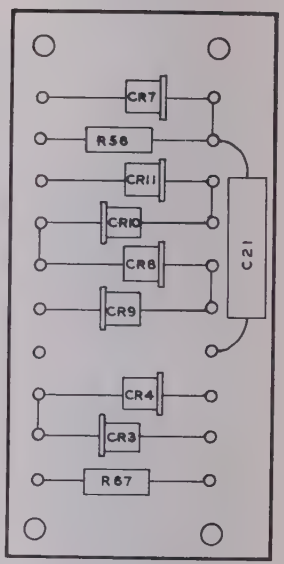


Bottom

Terminal Board "B"

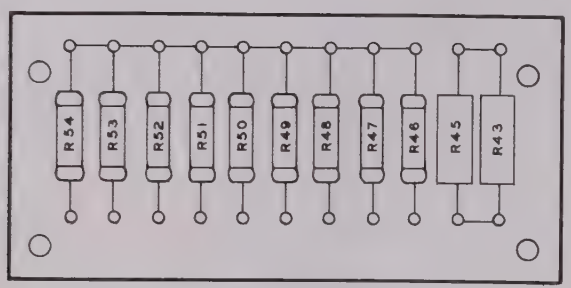


Top

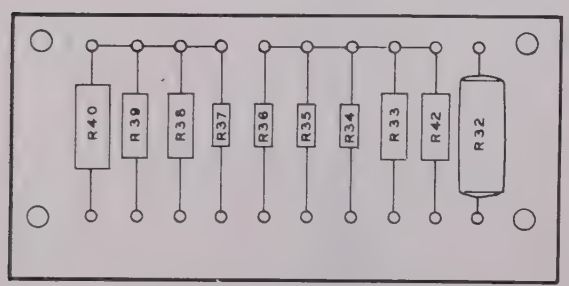


Bottom

Terminal Board "D"



Terminal Board "C" — Top



Terminal Board "C" — Bottom

Figure 24. Terminal Boards — Detail Views

ELECTRICAL COMPONENTS

Reference Symbol	*Value*	*Description*	*BRC Part No.*	*Mfg. Type No.*
C1	0.1μf	Cap., Fixed: ±20%, 400V, mylar paper	83121	Sprague 4TMP-1
C2	0.001μf	Cap., Fixed: ±2%, 500WVDC, mica	83005-1	
C3,4	0.00015μf	Cap., Fixed: ±20%, 500WVDC, mica	82437	Sprague 1FM-315
C5	0.01μf	Cap., Fixed: ±20%, 300V, mica	83005-10	
C6,7	1μf	Cap., Fixed: ±10%, 200V, mylar paper	82435	Sprague 2TM-M1
C8	0.00033μf	Cap., Fixed: ±20%, 500V, mica	82438	Sprague 1FM-333
C9	0.0005μf	Cap., Fixed: ±20%, 500V, mica	82440	Sprague 1FM-35
C10	0.001μf	Cap., Fixed: ±2%, 500WVDC, mica	83005-1	
C11	1μf	Cap., Fixed: ±1%, 100V, mylar	83125	Good-All 663-A
C13,14	0.003μf	Cap., Fixed: ±10%, 600WVDC, mylar paper	82436	Sprague 6TM-D3
C15	1μf	Cap., Fixed: ±1%, 100V, mylar	83125	Good-All 663-UW
C16	0.1μf	Cap., Fixed: ±20%, 400V, mylar paper	83121	Sprague 4TMP-1
C17	1μf	Cap., Fixed: ±10%, 200V, mylar paper	82435	Sprague 2TM-M1
C18	50μf	Cap., Fixed: +100%, −10%, 15V, electrolytic w/paper cover	82465	Good-All E306N
C19A-D	4x20μf	Cap., Fixed: 450V, electrolytic w/paper cover	83119	Sangamo PLQ-4S20
C20	0.1μf	Cap., Fixed: ±20%, 400V, mylar paper	83121	Sprague 4TM-P1
C21	12μf	Cap., Fixed: 250V, electrolytic	83135	C. D. BBR 12-250
C22A,B	2x20μf	Cap., Fixed: 450V, electrolytic w/paper cover	83140	C. D. Type UP2245
C23	16μf	Cap., Fixed: 150V, electrolytic	83136	C. D. BBR 16-150
C24	1μf	Cap., Fixed: ±1%, 100V, mylar	83125	Good-All 663-UW
C25,26	20μf	Cap., Fixed: 450V, electrolytic w/paper cover	83137	C. D. type AO 460
C27,28	0.1μf	Cap., Fixed: ±20%, 400V, mylar paper.	83121	Sprague 4TMP-1
C29	500μf	Cap., Fixed: 25V, electrolytic with Vinyl insulating sleeve	83139	
C31	0.5μf	Cap., Fixed: ±20%, 400V, mylar film	83115	Good-All 663UW
C32	0.1μf	Cap., Fixed: +80%, −20%, 600V, flat plate	83071	Centralab DF-104
C33	0.1μf	Cap., Fixed: ±20%, 400V, mylar paper	83121	Sprague 4TMP-1
C34	0.001μf	Cap., Fixed: +80% −20%, 600V, cer. disc	82306	Centralab DA140-002A
C35,36	0.01μf	Cap., Fixed: +80% −20%, 600V, cer. disc	82428	Centralab DA048-003
C37	1μf	Cap., Fixed: GMV, 3VDC, cer. disc	83145	Centralab UK105
C38	8-60μμf	Cap., Var.: Mica Compression Trimmer	84092	ARCO NO. 40-404
C39	0.01μf	Cap., Fixed: +80% −20%, 600V, cer. disc	82428	Centralab DA048-003A
CR1,2		Crystal Diode	91091	Transistron 1N54A
CR3,4		Crystal Diode	91100	RCA 1N-1763
CR5		Zener Diode	91101	H-P G-316-7A
CR6-12		Crystal Diode	91100	RCA 1N-1763
F1		Fuse: 3 amp.	95032	Littlefuse 313003
I1		Lamp: 3W, 120V	90907	G. E. #3S6/5
I2		Lamp, Incandescent: .15 Amp, 6-8V	90904	G. E. #47
J1		Terminal Strip, 2 Contacts	90059	Cinch-Jones 2-141-Y
J2		Jack, Open Circuit	89038	Switchcraft #11
J3		Socket: 12-pin	303566	Jones #S-312-AB
L1	10h,400Ω	Choke	306486	Freed RGC-4
L2		Choke	306487	Freed RGC-20
L3	10h,400Ω	Choke	306486	Freed RGC-4
M1		Meter	307167-2A	
P3		Plug: 12-pin	303565	Jones #P-312-CCT
R1	2.4KΩ	Res., Fixed: ±5%, ½W, Comp.	80223	A-B EB
R2	100KΩ	Res., Fixed: ±5%, ½W, Comp.	80517	A-B EB
R3	1 Meg. Ω	Res., Fixed: ±5%, ½W, Comp.	80621	A-B EB
R4	220KΩ	Res., Fixed: ±5%, ½W, Comp.	80555	A-B EB
R5	160KΩ	Res., Fixed: ±1%, ½W, Carbon film	80546	Electra EKC
R6	1KΩ	Res., Fixed: ±5%, ½W, Comp.	80148	A-B EB
R7	1 Meg.	Res., Fixed: ±5%, ½W, Comp.	80621	A-B EB
R8	470KΩ	Res., Fixed: ±5%, ½W, Comp.	80640	A-B EB
R9	4.7KΩ	Res., Fixed: ±5%, 2W, Comp.	80389	A-B HB
R10	470Ω	Res., Fixed: ±5%, ½W, Comp.	80168	A-B EB
R11	2.2KΩ	Res., Fixed: ±5%, ½W, Comp.	80256	A-B EB
R12	160KΩ	Res., Fixed: ±1%, ½W, Carbon film	80546	Electra EKC

Reference Symbol	*Value*	*Description*	*BRC Part No.*	*Mfg. Type No.*
R13	100KΩ	Res., Fixed: ±5%, ½W, Comp.	80517	A-B EB
R14	470KΩ	Res., Fixed: ±5%, ½W, Comp.	80640	A-B EB
R15	330Ω	Res., Fixed: ±5%, ½W, Comp.	80172	A-B EB
R16	16KΩ	Res., Fixed: ±5%, 1W, Comp.	80380	A-B EB
R17	2.2KΩ	Res., Fixed: ±5%, ½W, Comp.	80256	A-B EB
R18	3.9KΩ	Res., Fixed: ±5%, ½W, Comp.	80287	A-B EB
R19	1 Meg. Ω	Res., Fixed: ±5%, ½W, Comp.	80621	A-B EB
R20	3.9KΩ	Res., Fixed: ±5%, ½W, Comp.	80287	A-B EB
R21	1 Meg. Ω	Res., Fixed: ±5%, ½W, Comp.	80621	A-B EB
R22	1KΩ	Res., Fixed: ±5%, ½W, Comp.	80148	A-B EB
R23	1 Meg. Ω	Res., Fixed: ±5%, ½W, Comp.	80621	A-B EB
R24	8.2KΩ	Res., Fixed: ±5%, ½W, Comp.	80326	A-B EB
R25	2.5KΩ	Res., Var.: ±10%, 2W, W.W.	81076	A-B EB
R26	1 Meg. Ω	Res., Fixed: ±5%, ½W, Comp.	80621	A-B EB
R27	33KΩ	Res., Fixed: ±5%, ½W, Comp.	80461	A-B EB
R28	2.5KΩ	Res., Fixed: ±5%, 10W, W.W. Ceramic	80226	Sprague Type 10KT
R29	56Ω	Res., Fixed: ±5%, ½W, Comp.	80710	A-B EB
R30	220Ω	Res., Fixed: ±5%, ½W, Comp.	80188	A-B EB
R31	250KΩ	Res., Var.: ±10%, 2W, Comp.	81601	A-B Type J
R32	22KΩ	Res., Fixed: ±1%, 2W, W.W.	80450	Prec. Res. Corp. TX3716
R33	470KΩ	Res., Fixed: ±5%, 1W, Comp.	80613	A-B GB
R34	180KΩ	Res., Fixed: ±5%, ½W, Comp.	80558	A-B EB
R35	100KΩ	Res., Fixed: ±5%, ½W, Comp.	80517	A-B EB
R36	39KΩ	Res., Fixed: ±5%, ½W, Comp.	80452	A-B EB
R37	3.3KΩ	Res., Fixed: ±5%, ½W, Comp.	80253	A-B EB
R38	1.8KΩ	Res., Fixed: ±5%, 1W, Comp.	80282	A-B GB
R39	820Ω	Res., Fixed: ±5%, 1W, Comp.	80762	A-B GB
R40	240Ω	Res., Fixed: ±5%, 2W, Comp.	80115	A-B HB
R41A,B	500Ω, 25KΩ	Res., Var.: ±10%, 2W, WW, Dual	81422	
R42	1 Meg. Ω	Res., Fixed: ±5%, 1W, Comp.	80625	A-B GB
R43	220Ω	Res., Fixed: ±5%, 2W, Comp.	80414	A-B HB
R44	680KΩ	Res., Fixed: ±5%, ½W, Comp.	80663	A-B EB
R45	180Ω	Res., Fixed: ±5%, 2W, Comp.	80760	A-B HB
R46	2KΩ	Res., Fixed: ±½%, ½W, W.W.	80283	IRC WLA ⅝
R47	500Ω	Res., Fixed: ±½%, ½W, W.W.	80690	IRC WLA ⅝
R48	222.22Ω	Res., Fixed: ±½%, ½W, W.W.	80691	IRC WLA ⅝
R49	105.26Ω	Res., Fixed: ±½%, ½W, W.W.	80692	IRC WLA ⅝
R50	40.816Ω	Res., Fixed: ±½%, ½W, W.W.	80693	IRC WLA ⅝
R51	20.202Ω	Res., Fixed: ±½%, ½W, W.W.	80694	IRC WLA ⅝
R52	10.050Ω	Res., Fixed: ±½%, ½W, W.W.	80695	IRC WLA ⅝
R53	4.008Ω	Res., Fixed: ±½%, ½W, W.W.	80696	IRC WLA ⅝
R54	2.002Ω	Res., Fixed: ±½%, ½W, W.W.	80697	IRC WLA ⅝
R55	180Ω	Res., Fixed: ±5%, ½W, W.W.	80689	IRC WLA ⅝
R56	18KΩ	Res., Fixed: ±5%, 1W, Comp.	80406	A-B GB
R57	750Ω	Res., Var.: ±10%, 2W, W.W.	81130	CTS-IRC WPRL750
R58	30Ω	Res., Var.: ±10%, 2W, W.W.	81077	CTS-IRC WPRL-30
R59	470KΩ	Res., Fixed: ±5%, ½W, Comp.	80640	A-B EB
R60	100KΩ	Res., Var.: ±10%, ½W, Comp.	81614	CTS-IRC Type Q
R61	1 Meg. Ω	Res., Fixed: ±10%, ½W, Comp.	80655	A-B EB
R62	200Ω	Res., Var.: ±3%, 5W, W.W.	81129	Helipot Series A
R63	650Ω	Res., Fixed: 20W, W.W. Ceramic	80248	Clarostat PR-20K
R64	2.7 Meg. Ω	Res., Fixed: ±10%, ½W, Comp.	80634	A-B EB
R65	25KΩ	Res., Fixed: ±5%, 5W, W.W.	80410	Sprague 5KT
R66	10KΩ	Res., Fixed: ±5%, 2W, Comp.	80334	A-B HB
R67	33KΩ	Res., Fixed: ±5%, 1W, Comp.	80488	A-B GB
R68	30Ω	Res., Var.: ±10%, 2W, W.W.	81077	CTS-IRC WPRL30
R69	1.1Ω	Res., Fixed: ±5%, ½W, W.W.	80738	IRC WLA ⅝
R70	33KΩ	Res., Fixed: ±5%, ½W, Comp.	80461	A-B EB
R71	33KΩ	Res., Fixed: ±5%, 2W, Comp.	80420	A-B HB
R72A,B	250Ω, 50KΩ	Res., Var.: ±10%, 2W, W.W. Dual	81617	
R73	15KΩ	Res., Fixed: ±5%, ½W, Comp.	80336	A-B EB
R74	100KΩ	Res., Fixed: ±5%, ½W, Comp.	80517	A-B EB

Reference Symbol	*Value*	*Description*	*BRC Part No.*	*Mfg. Type No.*
R75	820Ω	Res., Fixed: ±5%, ½W, Comp.	80171	A-B EB
R76	5.6KΩ	Res., Fixed: ±5%, ½W, Comp.	80256	A-B EB
R77	2.2KΩ	Res., Fixed: ±5%, ½W, Comp.	80376	A-B EB
R78	12KΩ	Res., Fixed: ±5%, 1W, Comp.	80441	A-B GB
R79	47KΩ	Res., Fixed: ±5%, 2W, Comp.	80494	A-B HB
R80	18KΩ	Res., Fixed: ±½%, ½W, W.W.	80586	IRC RB
R81	48KΩ	Res., Fixed: ±½%, ½W, W.W.	80587	IRC RB
R82	98KΩ	Res., Fixed: ±½%, ½W, W.W.	80588	IRC RB
R83	198KΩ	Res., Fixed: ±½%, ½W, W.W.	80589	IRC RB
R84	498KΩ	Res., Fixed: ±½%, ½W, W.W.	80590	IRC RB
R85	998KΩ	Res., Fixed: ±½%, 1W, W.W.	80591	IRC SB
R86	1KΩ	Res., Fixed: ±¼%, ½W, W.W.	80686	IRC RB
R87	100Ω	Res., Fixed: ±¼%, ½W, W.W.	80687	IRC RB
R88	15Ω	Res., Var.: ±10%, 2W, W.W.	81078	CTS-IRC Type 2W
R89	1.2KΩ	Res., Fixed: ±5%, 2W, Comp.	80278	A-B HB
R90	47Ω	Res., Fixed: ±5%, 1W, Comp.	80740	A-B GB
R91	27KΩ	Res., Fixed: ±5%, 1W, Comp.	80487	A-B GB
R92	25KΩ	Res., Var.: ±10%, 2W, W.W.	81139	CTS-IRC WPRL2500
R93	8.2Ω	Res., Fixed: ±5%, ½W, W.W.	80730	IRC BW½
R94	5.6Ω	Res., Fixed: ±5%, ½W, Comp.	80376	A-B EB
R95	10KΩ	Res., Fixed: ±5%, ½W, Comp.	80361	A-B EB
R96	51Ω	Res., Fixed: ±5%, ½W, Comp.	80088	A-B EB
R97	33KΩ	Res., Fixed: ±5%, 1W, Comp.	80488	A-B GB
R98	180Ω	Res., Fixed: ±5%, 2W, Comp.	80760	A-B HB
R99	10KΩ	Res., Fixed: ±5%, 1W, Comp.	80331	A-B GB
S1		Switch, Toggle: DPST	88059	
S2		Switch, Rotary: SET-CHECK-MIN	306470	
S3		Switch, Rotary: METER	306473	
S4		Switch, Rotary: NPN-PNP	306469	
S5		Switch, Rotary: α-h_{ib}-β	306472	
S6		Switch, Rotary: I_E Range	306471	
S7		Switch, Rotary: V_{CB} Range	306474	
T1		Transformer, Detector	306460	
T2		Transformer, Oscillator	306466	
T3		Transformer, Power Supply	306459	Acme T-40946
V1		Electron Tube 12AT7		
V2,3		Electron Tube 6BA6		
V4		Electron Tube 6C4		
V5		Electron Tube 0A2		
V6,7		Electron Tube 6DQ6A		
V8		Electron Tube 12AX7		
V9,10,11		Electron Tube 0G3		
V12		Electron Tube 6AH6		
V13		Electron Tube 6N030		

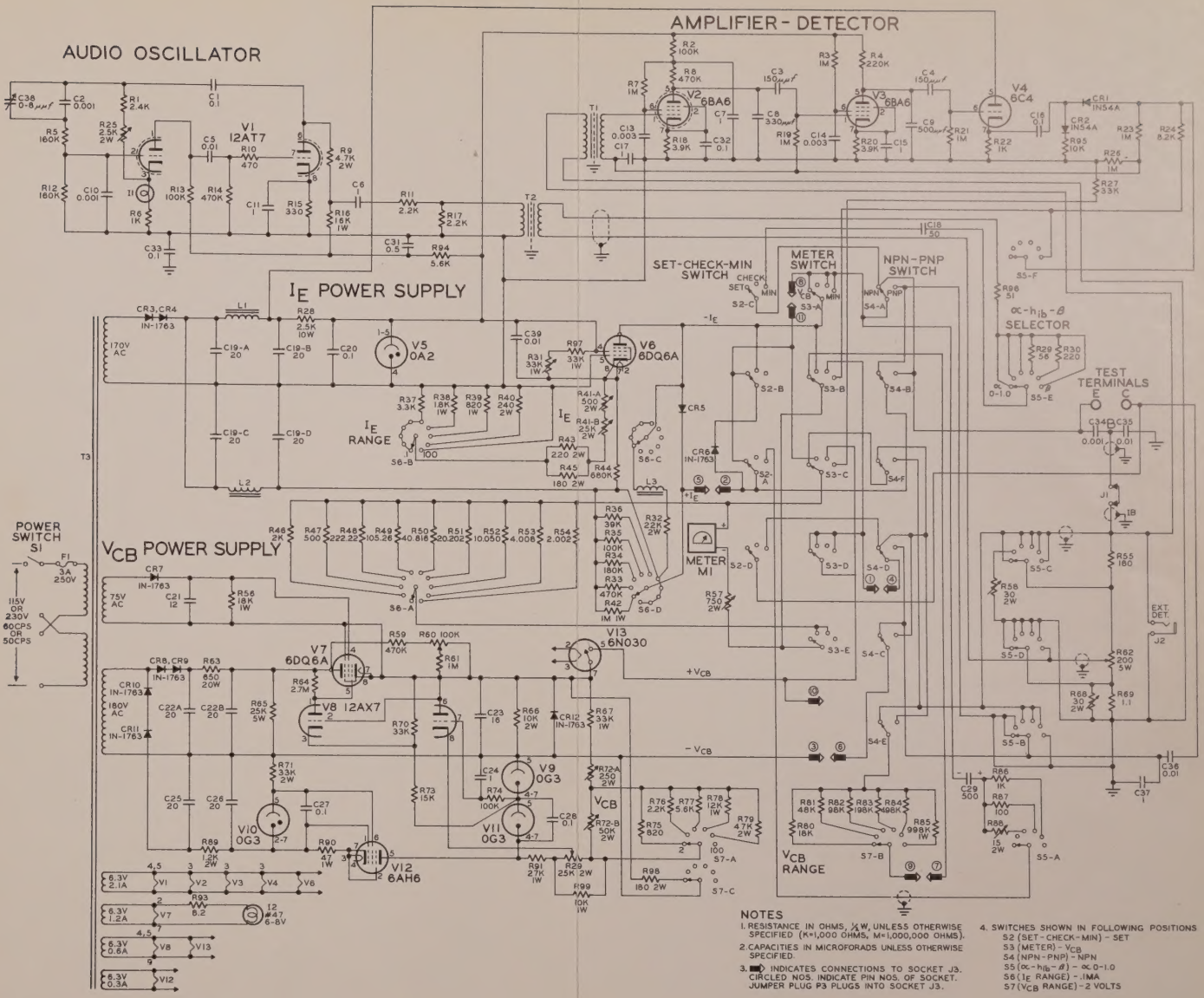


Figure 25. Schematic Diagram

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